

## Long-term trends in the recreational lobster fishery of Florida, United States: landings, effort, and implications for management

WILLIAM C. SHARP\*

RODNEY D. BERTELSEN

Florida Fish & Wildlife Conservation Commission  
Fish & Wildlife Research Institute  
2796 Overseas Highway  
Suite 119, Marathon  
FL 33050, United States

VERNON R. LEEWORTHY

National Oceanographic and Atmospheric  
Administration  
Office of Management and Budget  
1305 East West Highway  
N/MB72, Silver Spring  
MD 20910, United States

\*Present address: Florida Fish & Wildlife Conservation Commission, Division of Marine Fisheries Management, 2590 Executive Center Circle E., Suite 201, Tallahassee, FL 23201, United States. email: bill.sharp@myfwc.com

**Abstract** In Florida, United States, the Caribbean spiny lobster, *Panulirus argus*, supports an important commercial fishery and also perhaps the most intensive recreational fishery of any lobster species, with sales of recreational lobster fishing permits exceeding 100 000 annually. For the past decade, we have used mail surveys of recreational lobster license holders to estimate spatially explicit landings and fishing effort when recreational fishers are most active—during the state’s “Special Two-Day Sport Season”, which takes place just before the opening of the commercial season, and during the first month of the regular recreational season, which coincides with the commercial season. From 1993 through 2002, fishing effort during the Special Two-Day Sport Season has ranged from 60 000 to 112 000 person-days, and landings have ranged from c. 112 to 255 t. Both fishing effort and landings have varied

without trend. Fishing effort during the regular season over the same period has ranged from 261 000 to 514 000 person-days, and landings have ranged from 434 to 825 t. Fishing effort has shown a marginally statistically significant decreasing trend, the result of a progressive decrease in effort since 1999. The largest proportion of both fishing effort and landings was concentrated along the south-east coast. Despite the recent decrease in landings, the proportion of total landings made by the recreational fishery has increased. From 1993 through 1998, the fishery was responsible for c. 30% of commercial landings; by 2001, that percentage increased to nearly 40%. Such a shift in landings away from the commercial trap fishery toward the recreational fishery was recognised as a potential but unintended effect of the ongoing management plan of restricting effort in the commercial trap fishery. Our 2001 surveys revealed that recreational lobster fishers spent more on a person-day basis than the general visitor to the Florida Keys did, but less than those visitors using the region’s coral reefs. Consequently, managers must establish management strategies that allow the coexistence of this resource’s user groups and also incorporate the social and environmental concerns of nonuser groups.

**Keywords** Caribbean spiny lobster; *Panulirus argus*; recreational fishery; mail survey

### INTRODUCTION

The Caribbean spiny lobster, *Panulirus argus* Latreille, 1804, has been harvested in commercial quantities in Florida, United States, for more than 100 years. For the past several decades, it has consistently been the state’s first or second most valuable fishery, with an annual ex-vessel value of c. US\$30 million (Muller et al. 1997). About 90% of the state’s landings occur along Florida’s extreme south-eastern coast, especially along the Florida Keys archipelago. The warm, shallow waters of the Florida Keys are also conducive to a popular recreational fishery for the species.

Before 1991, this recreational fishery was completely open access, managed only through a spawning season closure, a personal daily bag limit, and gear restrictions. Effort by the recreational fishery was unknown, and the only estimate of landings by this fishing sector was accomplished using a Delphi exercise (Linstone & Turroff 1975) that estimated them to be equal to c. 10% of commercial landings (Zuboy 1980). In 1991, Florida instituted a recreational spiny lobster license, purchased as an additional endorsement to the state's saltwater fishing license (required by all fishers more than 16 years old except Florida residents more than 65 years old). The additional permit allowed the state's fishery scientists to identify potential recreational lobster fishers and estimate their lobster fishing effort and landings.

In 1991, using a mail survey of persons purchasing a lobster permit, we estimated that 50 000 people fished for lobsters during the opening month of the lobster fishing season and landed c. 957 t of lobsters, or 22% of the state's total lobster landings (Hunt 1994). The results of this survey underscored the importance of collecting detailed information about this fishing sector to manage the Florida *P. argus* fishery effectively. Therefore, we have continued to conduct annual mail surveys to estimate and evaluate trends in statewide and regional lobster landings, fisher participation, and fishing effort, and to provide a means to evaluate this user group's perceptions and opinions about the fishery.

The primary recreational lobster fishing season coincides with the commercial season and extends from 6 August through 31 March. Commercial trap fishers are allowed to place lobster traps in the water five days before the opening of their season to allow them to soak. In 1975, the state's fishery managers instituted the "Special Two-Day Sport Season" that is held during the last week of July to compensate recreational fishers for this concession to the commercial fishery and to reduce user conflicts on the opening day of the regular lobster fishing season. During the Special Two-Day Sport Season, recreational fishers are permitted 6 lobsters per person per day in the Florida Keys and 12 lobsters per person per day in other areas of the state. The bag limit during the regular lobster fishing season is 6 lobster per person per day, or 24 per boat per day, whichever is greater. Recreational fishers are not permitted to capture lobsters with traps. Diving (breath-hold, SCUBA, or hookah) and "bully nets", which are used by fishers from boats to ensnare lobsters in shallow water, are the only allowable fishing methods. Divers are not permitted to use any

device to capture lobsters that could puncture a lobster's exoskeleton.

Each year, we conduct two separate mail surveys of recreational lobster license holders. One survey includes a questionnaire that queries license holders about their lobster fishing activities during the Special Two-Day Season, and the other surveys a separate group of license holders about their lobster fishing activities from the opening day of the regular season through the Labor Day holiday (the first Monday in September). We restrict the regular season survey to this period because our experience indicated that the majority of fishing effort occurred during the first month of the season, and fishers would have more difficulty accurately recalling their fishing activities many months later. We did, however, conduct one end-of-season mail survey at the conclusion of the 1994 season to obtain an estimate of fishing effort and landings during the remainder of the lobster fishing season. Additionally, from 1993 through 1996 our annual mail surveys asked fishers about their intentions to fish for lobsters after our survey period.

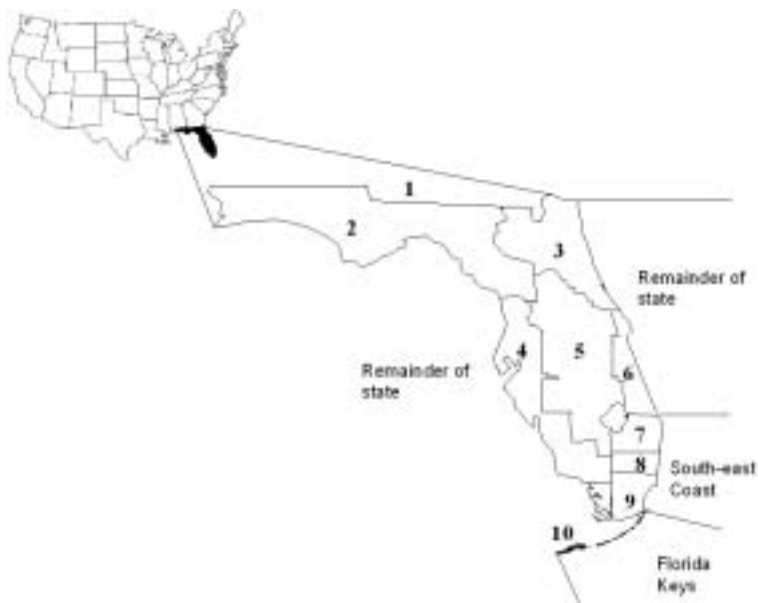
Here, we present an overview of the recreational *P. argus* fishery in Florida. We present statewide and regional trends in landings and fishing effort from 1993 through 2002 during the Special Two-Day Sport Season and the first month of the regular lobster fishing season. We also present the results from the mail survey conducted at the conclusion of the 1994 season and a socio-economic profile of the fishery that was collected during the 2001 season's mail survey. Finally, we discuss the management issues that the state's fisheries managers are currently facing associated with the *P. argus* fishery in Florida.

## MATERIALS AND METHODS

### Mail surveys

Recipients of our mail surveys were randomly selected from the state's saltwater fishing license database of individuals who purchased a lobster permit that was valid during our survey period. To ensure that this selection process did not over- or under-sample any geographic region, these selections were stratified based upon license sales in each of 10 residence areas defined by postal codes (Fig. 1). The number of lobster license holders we attempted to survey each season has ranged from 4000 to 5000, with an exception in 2001. That year's survey included a detailed socio-economic component, which necessitated a much more detailed

**Fig. 1** Map of Florida, United States. Areas denoted by numerals are the 10 residence areas defined by postal codes. Relative sales of recreational lobster license in each region were used to stratify the random selections of mail survey recipients. “1” refers to all areas in the United States outside of Florida. Areas referred to as “Florida Keys” and “south-east coast” are zones from which we report regional lobster landings and fishing effort. All lobster landings and fishing effort outside of these two zones are referred to as “remainder of state”.



questionnaire than those mailed during other years. In anticipation of a decreased response rate resulting from the additional length, we attempted to survey 10 000 license holders.

The general methodology of our mail survey followed the “Total Design Method” (Dillman 1978). Surveys were mailed to the license holders chosen to receive a questionnaire about the Special Two-Day Sport Season 1 week after the end of that season, and those chosen to receive a regular-season questionnaire were mailed their surveys 1 week after Labor Day. A personally addressed, signed cover letter and a postage-paid return envelope accompanied each questionnaire (see Sharp et al. 2004). We guaranteed anonymity to each survey respondent. One week after the initial mailings, each addressee was mailed a “thank you/reminder” postcard. Survey recipients who had not returned their questionnaires after having them for c. 7 weeks were sent a reminder letter and a replacement questionnaire. To provide an incentive for recipients to return their completed questionnaires, we offered each recipient the option of receiving a brief summary of the results of the survey.

### Landings and fishing effort models

Landings and fishing effort were derived from the questionnaires for a particular survey by estimating the number of fishers participating in a particular season, the time (in days) they fished for lobster, and their lobster catch rate (lobsters per day). We used a sampled randomisation technique (Monte Carlo) to

calculate these basic parameters (Sokal & Rohlf 1981). This method entailed generating 1000 independent bootstrap samples. Samples were weighted by geographic residence areas (Fig. 1) based on the proportion of the total number of surveys mailed to each area. We have found that lobster catch rates of recreational fishers can vary considerably between those areas, as do the recreational fishers’ response rates (Bertelsen & Hunt 1991). This weighting factor ensures that one area is not over-sampled relative to the others. Equations 1–6 below describe the detailed calculations used to estimate landings and fishing effort (person-days) during the Special Two-Day Sport Season for each of the 1000 bootstrapped samples.

For each residence area, we calculated the number of licensed lobster fishers that fished for lobster during the survey period. The percentage of those that fished for lobster during the survey period was then multiplied by the number of lobster licenses sold that year to persons that lived in each of our defined residence areas to determine the total number of licensed fishers residing in each of those areas that fished for lobster:

$$LF_r = \left( \sum L_r \times P_r \right) \quad (1)$$

where LF = number of licensed fishers; L = number of lobster licenses estimated to be valid during the survey period; P = proportion of survey respondents that fished for lobster during the survey period; and r = residence region.

We determined in which of three fishing zones those persons fished for lobster (Fig. 1) by estimating the number of licensed fishers in each zone on the first and second day of the season using Equation 2. This equation yielded the number of fishers in each zone from each residence area on each day. The total number of fishers in each zone was then determined by summing the number of persons from all the residence areas that fished in a particular zone:

$$LF_{zd} = \left( LF_r \times \frac{\sum n_{rzd}}{\sum n_r} \right) \quad (2)$$

where LF = number of licensed lobster fishers; n = survey respondents that fished for lobster; r = residence area; z = fishing zone; d = day of the season.

We determined the number of fishing parties (NG) in each fishing zone on each day using Equation 3. We estimated this by dividing the number of licensed fishers (LF) in that zone by the mean licensed group size. If we included non-licensed lobster fishers (i.e., those younger than 16 and Florida residents older than 65), this calculation would underestimate the total number of fishing groups in each fishing zone. Therefore, the non-licensed fishers (NL) were subtracted from the total fishing party size (GZ). The number of groups fishing in each fishing zone was equal to the number of licensed fishers that fished in a given zone (LF<sub>j</sub>), divided by the average licensed group size:

$$NG_{zd} = \frac{LF_{zd}}{\left( \frac{\sum GZ_{zd}}{n_{zd}} - \frac{\sum NL_{zd}}{n_{zd}} \right)} \quad (3)$$

where NG = number of lobster fishing parties; GZ = number of persons in the fishing party (includes both licensed and non-licensed persons); NL = number of non-licensed fishers in the party; and n = number of observations.

We calculated lobster landings separately for the first and second day of the season in each zone using Equation 4. This was equal to the mean number of lobsters caught per fishing party (GC), multiplied by the number of fishing parties (NG) found in Equation 3. Landings for each day in each fishing zone were then summed to estimate total landings:

$$L_{zd} = GC_{zd} \times NG_{zd} \quad (4)$$

where L = lobster landings (number of lobsters).

We calculated the number of person-days in each fishing zone on each day using:

$$PD_z = \sum D_{zd} \times GZ_{zd} \quad (5)$$

where PD = number of person-days; D = number of days spent lobster fishing.

Estimating fishing effort and landings for the regular season involved most of the same steps described above. However, because the survey period extends about 1 month, survey recipients were asked about their average daily lobster landings and fishing party size. Therefore, Equations 1 through 3 were based upon the respondents' average daily fishing activities. To estimate landings during the regular season, we first calculated the average number of days the respondents fished in each fishing zone (D<sub>z</sub>). Then, for each fishing zone, we multiplied that value by the average fishing-party catch rate (GC) and the number of fishing parties (NG) (Equation 6):

$$L_z = GC_z \times NG_z \times D_z \quad (6)$$

We then converted our estimated landings, which are in numbers of lobsters, into an estimate of weight using the equation of Matthews et al. (2003):

$$LWT_j = 0.001989 \times CL^{2.80327}$$

where LWT = lobster landings (g); and CL = mean carapace length of lobsters landed by the commercial fishery during the survey period.

We evaluated temporal trends in license sales, the number of people who used their licenses, lobster landings, fishing effort, and catch per unit effort by using the non-parametric Mann-Kendall sign test and Sen's estimator of slope (Gilbert 1987). When evaluating trends in lobster landings and person-days that were generated by the sampled randomisation procedure, we used the mean value for those variables produced by the procedure.

### Socio-economic models

To estimate the socio-economic impact of recreational lobster fishing on the Florida Keys fishing region, the mail surveys of recreational lobster license holders during 2001 included a section asking each recipient to detail the expenditures associated with his or her lobster fishing activities. Using this information, we estimated total expenditures of survey respondents fishing for lobsters in the Florida Keys during the survey period by multiplying the mean expenditures per person-day of these respondents by the total estimated number of person-days of lobster fishing in the region.

**RESULTS**

**Survey response rates**

Effective survey response rates (the number of completed survey questionnaires returned to us out of the total number mailed, excluding surveys that did not reach the intended recipient because of an incorrect address) remained c. 60% each fishing season from 1993 through 1997 (Table 1). In 1998, we added questions to the survey to obtain fishers’ opinions about the fishery and some that were designed to examine fisher demographics in more detail than earlier surveys. Since the two surveys were lengthened, the combined return rates have ranged from 45% to 52%, the exception being in 2001, when the survey also included a socio-economic component that resulted in a multi-page questionnaire. The combined return rate from both surveys that season was 43%.

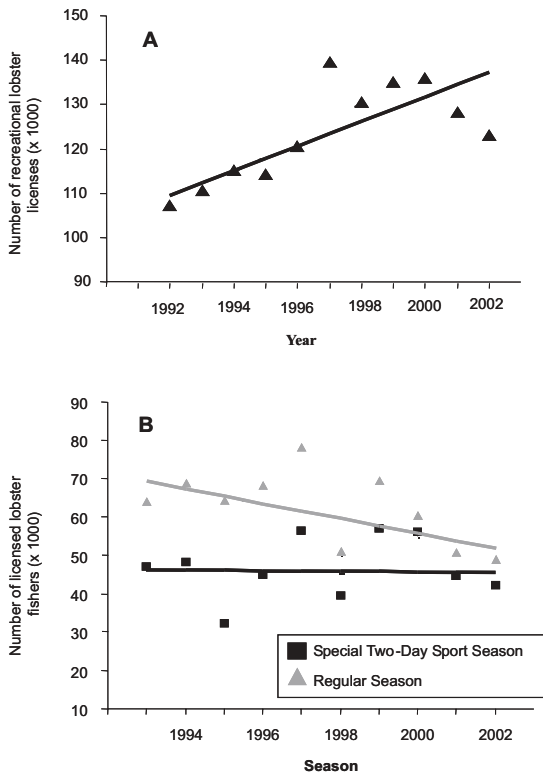
**Trends in license sales**

Annual sales of recreational lobster fishing licenses showed an increasing trend from 1992 through 2002 ( $Z = 2.18, P = 0.29$ ; Mann-Kendall sign test; Sen’s slope = 2779) (Fig. 2A). Sales increased steadily from 1992 through 2000, with the largest number of licenses sold being 139 553 in 1997. However, license sales decreased in successive years after 2000.

The number of license holders who used their licenses during the Special Two-Day Sport Season from 1993 through 2002, however, has not shown the same trend ( $Z = -0.18, P = 0.858$ ; Mann-Kendall sign test; Sen’s slope = -109); instead, it has fluctuated without trend from c. 32 500 (1995) to c. 57 000 persons (1999) (Fig. 2B). The number of license holders who used their licenses during the first month of the regular season ranged from

**Table 1** Number of questionnaires mailed to recreational lobster license holders, the number of completed questionnaires returned to the Florida Fish & Wildlife Conservation Commission, United States and the effective return rate. Effective return rate is the percentage of returned questionnaires out of the total, once undeliverable questionnaires were removed.

Season	No. of questionnaires		Undeliverable questionnaires	Effective response rate (%)
	Mailed	Returned		
<b>Special Two-Day Sport Season</b>				
1993	2491	1302	410	63
1994	2283	1184	402	63
1995	1996	983	327	59
1996	1998	962	377	59
1997	1981	984	311	59
1998	2076	1074	127	55
1999	1884	844	174	49
2000	2002	948	177	52
2001	4809	1974	466	45
2002	2500	1082	249	48
<b>Regular season</b>				
1993	2497	1189	459	58
1994	2295	1137	400	63
1995	1686	860	236	59
1996	1999	930	357	57
1997	2006	954	325	57
1998	1967	910	110	49
1999	2031	839	189	46
2000	2002	820	225	46
2001	5181	1883	523	40
2002	2500	972	287	44



**Fig. 2** A, Number of annual recreational lobster licenses sold, 1992–2002; and B, estimated number of recreational lobster license holders that used their licenses during the Special Two-Day Sport Season and during the first month of the regular lobster fishing season, 1993–2002. Solid line denotes Sen’s estimate of slope.

c. 49 000 (2002) to c. 78 000 (1997) but has decreased progressively each year since 1999, though a significant trend was not apparent ( $Z = -1.61$ ,  $P = 0.107$ ; Mann-Kendall sign test; Sen’s slope =  $-1954$ ).

**Fishing effort and landings**

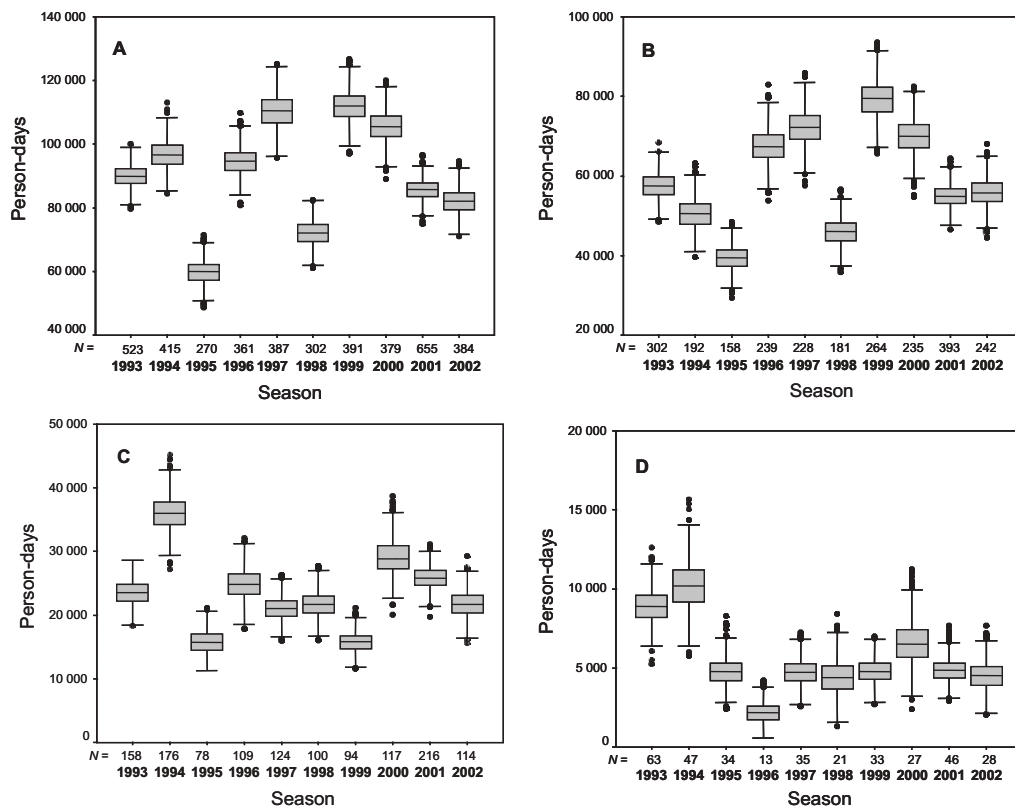
*Special Two-day Sport Season*

Fishing effort during the Special Two-Day Sport Season from the 1993 through the 2002 fishing seasons, expressed in terms of person-days, has generally mirrored the interannual variation in the number of lobster fishers who used their licenses and has not shown any detectable trends (Table 2). We estimate that fishing effort statewide has ranged from c. 60 000 to 112 000 person-days (Fig. 3). Fishing effort was concentrated in the Florida Keys, where effort has ranged from 39 000 to 79 000 and accounted for 64% or more of the statewide fishing effort estimate each season. Most of the remaining fishing effort occurred along the south-east coast of the state, where effort ranged from 16 000 to 36 000 person-days. Fishing effort throughout the remaining areas of the state ranged from c. 2000 to 10 000 person-days.

Annual landings during the Special Season have not shown any distinct temporal trends (Table 2) but have fluctuated more than 2-fold throughout the period, ranging from 112 to 255 t (Fig. 4). The largest proportion of landings occurred in the Florida Keys and have ranged from 73 to 179 t, or c. 60% to 70% of the annual statewide total. Landings along the

**Table 2** Results of nonparametric trend analysis on regional fishing effort and lobster landings during the Special Two-Day Sport Season from 1993 through 2002.

	Mann-Kendall sign test		Sen’s slope estimator		
	z	P	Slope	Confidence intervals	
				Upper	Lower
<b>Person-days</b>					
Statewide	0.00	1.000	- 529.7	4514.1	- 9899.7
Florida Keys	0.54	0.592	657.3	3669.2	-3775.6
South-east coast	0.00	1.000	-192.3	1387.5	-3107.9
Remainder of state	-0.54	0.592	-122.0	364.6	-970.5
<b>Lobster landings</b>					
Statewide	0.18	0.858	3.8	15.8	- 13.3
Florida Keys	0.18	0.858	10.0	61.4	- 41.3
South-east coast	0.00	1.000	-1.7	18.0	-26.6
Remainder of state	0.54	0.592	0.25	5.1	-3.1



**Fig. 3** Boxplots depicting the results of a Monte Carlo simulation estimating fishing effort during the Special Two-Day Sport Season: **A**, statewide; **B**, in the Florida Keys region, United States; **C**, south-east coast; and **D**, in the remaining areas of the state based upon mail survey returns, 1993–2002. Sample sizes listed along the horizontal axis represent the number of survey recipients, from the total number of questionnaires we received, that fished for lobsters.

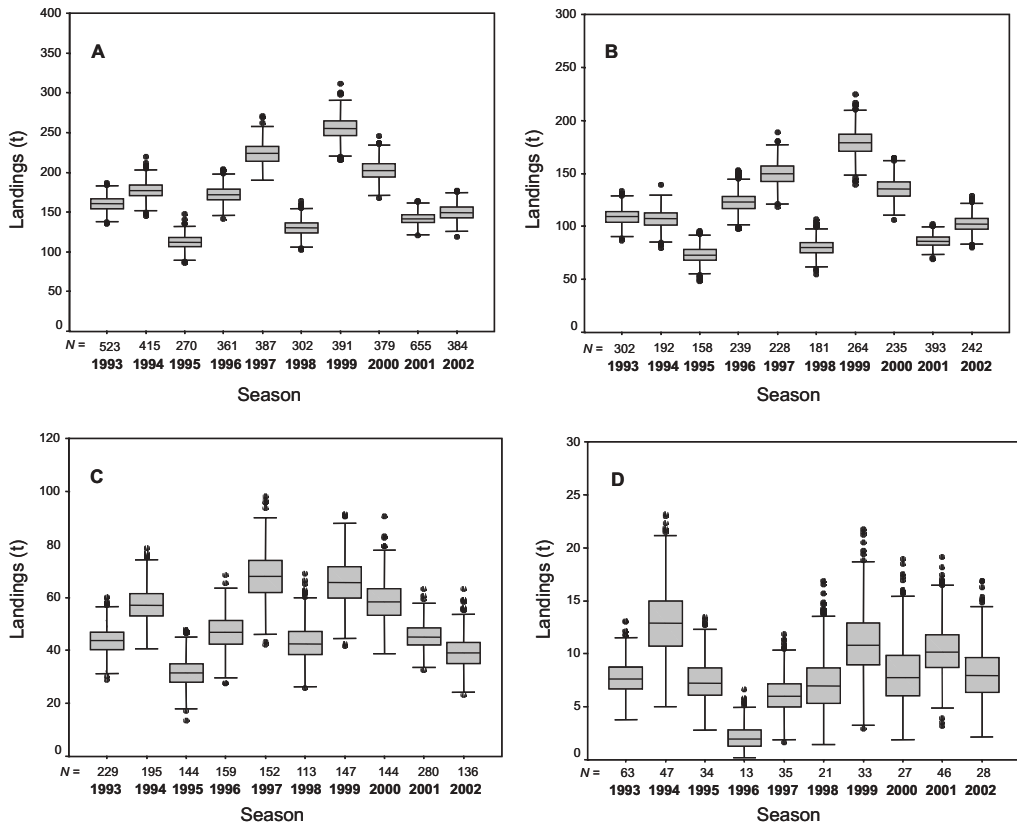
south-east coast during the Special Season ranged from 31 to 68 t, and those throughout the remainder of the state ranged from 2 to 13 t.

*Regular season*

We estimate that statewide fishing effort during our regular season survey period (i.e., 1993–2002) ranged from c. 261 000 to 514 000 person-days (Fig. 5). Regional fishing effort was proportionally similar to that of the Special Two-Day Sport Season. Fishing effort in the Florida Keys over the same period ranged from 168 000 to 366 000 person-days. Most of the remaining fishing effort occurred along the south-east coast of Florida, where effort ranged from 62 000 to 150 000 person-days. Effort in the rest of the state ranged from 25 000 to 66 000 person-days.

A marginally significant decreasing trend was detected in statewide fishing effort during the period,

and a similar significant trend was detected in the Florida Keys (Table 3). A statistically significant trend was not detected in fishing effort in the south-east coast region; however, fishing effort there has also progressively decreased (Fig. 5). This decrease in fishing effort shows the same general pattern as that observed in the number of license holders who used their licenses during our survey period, which also decreased progressively after the 1999 season (see Fig. 2B). However, the decrease in person-days in the Florida Keys was clearly not solely the result of fewer license holders using their licenses. Among survey respondents who did fish for lobsters in the Florida Keys, the mean number of days spent fishing also decreased progressively after the 1999 season. Although the number of days spent fishing had been relatively stable through 1999, this recent decrease resulted in a significant negative trend ( $Z = -2.71$ ,



**Fig. 4** Boxplots depicting the results of a Monte Carlo simulation estimating lobster landing during the Special Two-Day Sport Season: **A**, statewide; **B**, in the Florida Keys region, United States; **C**, the south-east coast; and **D**, in the remaining areas of the state based upon mail survey returns, 1993–2002. Sample sizes listed along the horizontal axis represent the number of survey recipients, from the total number of questionnaires we received, that fished for lobsters.

$P = 0.007$ ; Mann-Kendall sign test; Sen's slope =  $-0.093$ ) (Fig. 6).

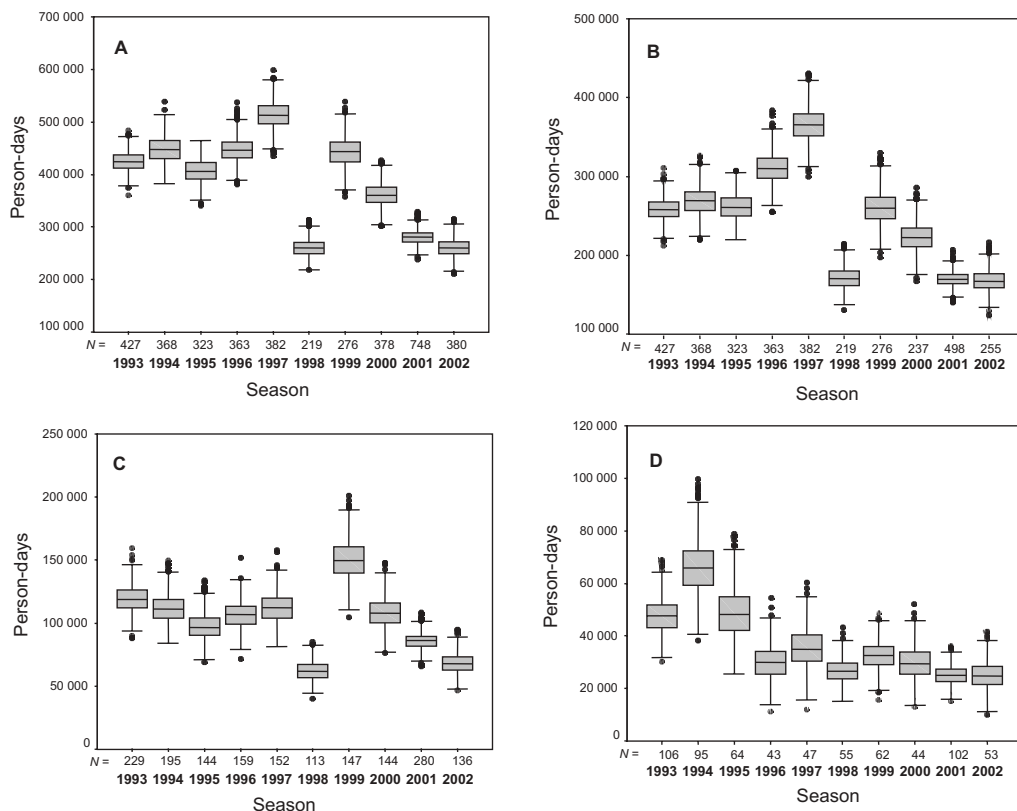
A significant decreasing trend in the number of person-days of lobster fishing was also detected in the areas outside the Florida Keys and south-east coast region (Table 3). However, the trend was different than that observed in the latter two regions. The number of person-days decreased noticeably from the 1995 to the 1996 season but has remained generally stable over subsequent seasons.

Statewide landings during the regular season survey period ranged from 434 to 825 t (Fig. 7). The largest proportion of landings occurred in the Florida Keys and ranged from 301 to 573 t. As with the Special Season, landings in that region accounted for 60 to 70% of the annual statewide total ( $\bar{x} \pm 1 \text{ SE} = 66$  (1.2%). Landings in the south-east coast ranged

from 301 to 201 t, and landings in the remainder of the state ranged from 29 to 76 t.

The decrease in fishing effort, both in terms of person-days and the number of days spent lobster fishing during our regular season survey period, has not yet resulted in a detectable trend in landings statewide or either in the Florida Keys and south-east coast regions. Yet, we note that landings in the Florida Keys have decreased progressively since the 1999 season, and those of the two most recently completed seasons represent two of the three lowest landings estimates since 1993.

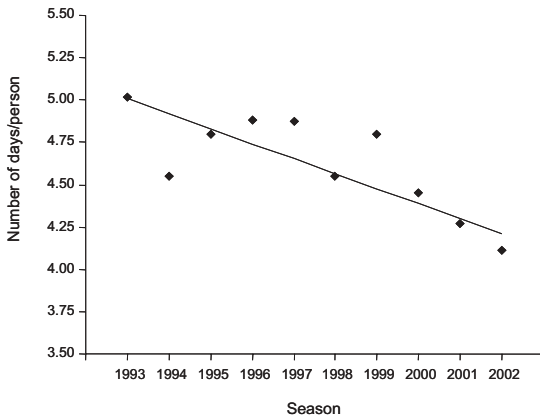
A highly significant decreasing trend was detected in lobster landings in areas outside the Florida Keys and south-east coast regions (Table 3; Fig. 7D) that generally followed the trend in fishing effort. Landings were generally similar from 1993



**Fig. 5** Boxplots depicting the results of a Monte Carlo simulation estimating fishing effort during the regular lobster fishing season; **A**, statewide; **B**, in the Florida Keys region, United States; **C**, the south-east coast; and **D**, in the remaining areas of the state based upon mail survey returns, 1993–2002. Sample sizes listed along the horizontal axis represent the number of survey recipients, from the total number of questionnaires we received, that fished for lobsters.

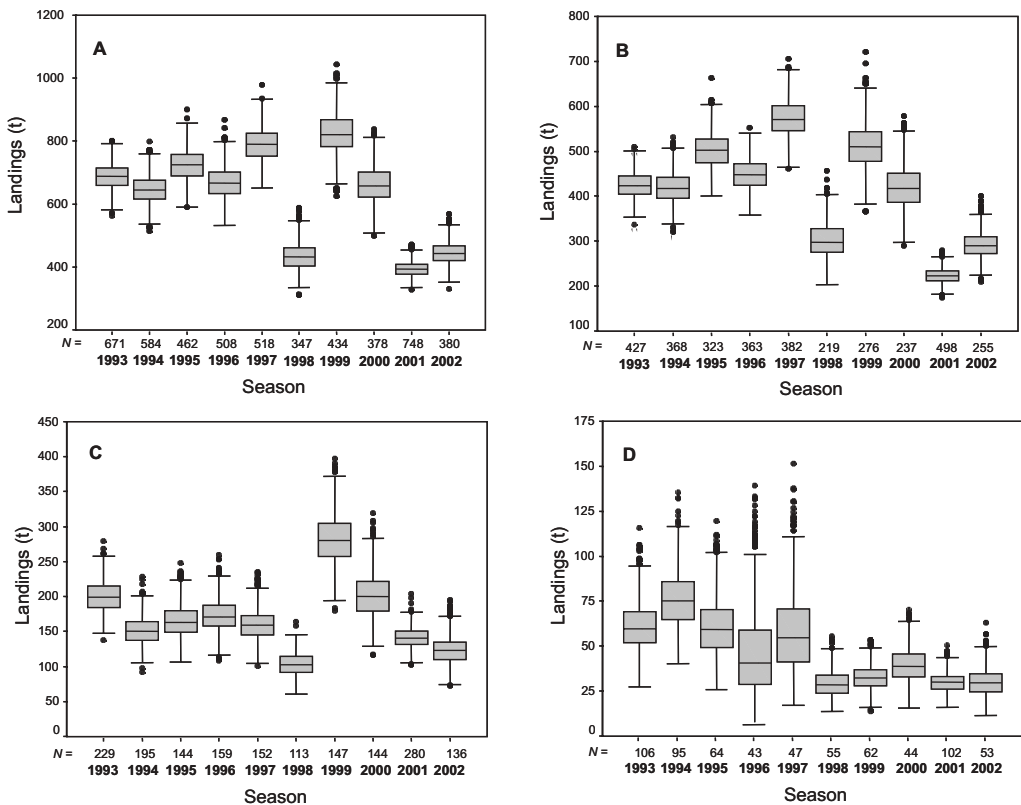
**Table 3** Results of non-parametric trend analysis on regional fishing effort and lobster landings during the Regular season survey period from 1993 through 2002.

	Mann-Kendall sign test		Sen’s slope estimator		
	<i>z</i>	<i>P</i>	Slope	Upper	Lower
<b>Person-days</b>					
Statewide	-1.79	0.074	-20 927.1	2995.8	-47 927.2
Florida Keys	-1.79	0.074	-12 727.8	339.0	-29 063.9
South-east coast	-1.25	0.211	-4154.6	2204.7	-11 514.1
Remainder of state	-2.68	0.007	-2829.0	-1015.5	-5872.44
<b>Lobster landings</b>					
Statewide	-1.07	0.283	-26.9	23.0	-56.6
Florida Keys	-1.07	0.283	-24.7	15.1	-51.6
South-east coast	-0.72	0.474	-5.8	8.6	-17.6
Remainder of state	-2.50	0.012	-4.8	-1.3	-6.6



**Fig. 6** Mean number of days spent lobster fishing by mail survey respondents that fished for lobster during the regular season in the Florida Keys, United States 1993–2002.

through 1997, and after a noticeable decrease in 1998 from earlier seasons, they remained similar through the remaining seasons. This marked difference in landings in this region coincided with a change in our survey questionnaire for the regular season in the way recipients indicated their lobster landings on a regional basis. Questionnaires before 1998 asked respondents to provide only one value for their daily lobster catch, even though many respondents fished in different regions of the state during the month, and the daily catch in these different areas was potentially very different. This likely caused a slight overestimate of landings in this region, because many of those respondents fished for lobsters in the Florida Keys and then in areas of the state where lobsters are much less abundant. From 1998 onward, the questionnaire was modified to allow respondents to provide their daily landings for each of our defined



**Fig. 7** Boxplots depicting the results of a Monte Carlo simulation estimating lobster landings during the regular lobster fishing season: **A**, statewide; **B**, in the Florida Keys region, united States; **C**, the south-east coast; and **D**, in the remaining areas of the state based upon mail survey returns, 1993–2002. Sample sizes listed along the horizontal axis represent the number of survey recipients, from the total number of questionnaires we received, that fished for lobsters.

fishing areas of the state (Fig. 1). We believe this change increased the accuracy and precision of our landings estimates. Though this bias was likely small, our landings estimates for the state outside of the Florida Keys and the south-east coast were based upon many fewer responses, and this bias, coupled with the small sample size, caused the detectable change in our landings estimates in the region.

### Recreational fisher demographics

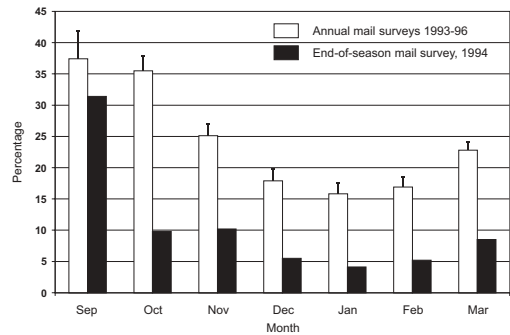
During each season of our survey period, a relatively consistent proportion of survey respondents indicated they fished for lobster during the Special Two-Day Sport Season only, the regular season, or both. An average ( $\pm 1$ SE) of 17% ( $\pm 1.4$ ) of respondents fished during the Special Season only, an average of 45% ( $\pm 1.2$ ) fished only during our regular season survey period, and an average of 39% ( $\pm 0.9$ ) fished during both periods.

Although the largest proportion of the recreational fishing effort occurs in the Florida Keys, most of that effort is the result of fishers travelling from other areas. During the course of our survey period, residents of the Florida Keys accounted for only c. 7–11% of the recreational lobster licenses sold annually. Non-residents of the Florida Keys have consistently accounted for c. 80% of the proportion of mail survey respondents that fished for lobster in the Florida Keys during both the Two-Day Special Sport Season and the regular season, and more than 60% of those respondents travelled further than 250 km to reach the Florida Keys. In comparison, 88% of survey respondents who fished along the south-east coast region during the Special Two-Day Sport Season lived in that area, and 80% of residents that resided in our south-east coast region fish for lobster in that region during our regular season survey period.

### Economic impact of the fishery on the Florida Keys

We estimate that lobster fishers visiting the Florida Keys spent US\$129.41 per person-day during the Special Two-Day Sport Season and US\$122.35 per person-day during our regular season mail survey period. Residents of the Florida Keys spent US\$33.99 during the Special Two-Day Sport Season and US\$42.83 during the regular season.

In all, we estimated that c. US\$24 million was spent on recreational lobster fishing in the Florida Keys during the 2001 mail survey period. Of that total, c. \$18 million (74%) was spent during the regular season and c. \$6.3 million (26%) was spent

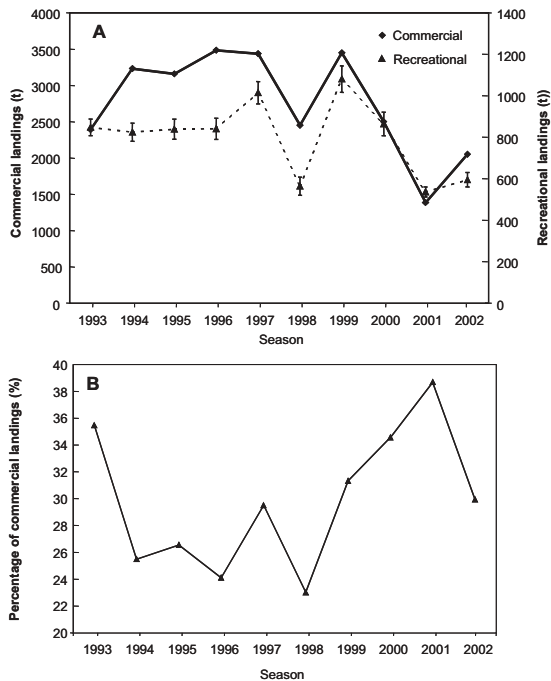


**Fig. 8** Mean ( $\pm 1$ SD) percentage of mail survey respondents that indicated they intended to fish after the Labor Day holiday, 1993–96, and the percentage of the 1994 end-of-season survey respondents that indicated they actually fished for lobster.

during the Special Two-Day Sport Season. Fishers who resided outside the Florida Keys accounted for c. \$22 million (92%) of the total monies spent on recreational lobster fishing in the Florida Keys.

### Post Labor Day fishing effort and landings

To obtain a coarse estimate of lobster fishing effort after the Labor Day holiday, our surveys from 1993 through 1996 included questions that asked respondents about which month they intended to fish for lobsters after the survey period. Nearly 60% of respondents of our regular season survey had fished for lobsters before Labor Day, but only 37% of respondents to both surveys indicated they intended to do so during the remainder of September, and that percentage progressively decreased during the subsequent months (Fig. 8). However, our end-of-season survey that was conducted after the conclusion of the 1994 lobster fishing season indicated that lobster fishing effort during those months was even lower than that indicated by respondents of the former surveys. Only 13% of those survey recipients indicated that they actually fished for lobsters after Labor Day, and no more than 10% of those respondents fished for lobster in any single month during the survey period (Fig. 8). From that same survey, we estimated that statewide there were only c. 50 673 ( $\pm 1$ SD = 9163) person-days of lobster fishing during that period and that 67 ( $\pm$  SD = 17) t of lobsters were landed. Because of the small number of surveys from which these estimates were derived ( $n = 52$ ), we did not attempt to estimate regional



**Fig. 9** Comparison of: **A**, total commercial and estimated recreational landings during the Special Two-Day Sport Season and the regular season through Labor Day; and **B**, those recreational landings expressed as a proportion of commercial landings, 1993–2002.

landings. Comparing this estimate with estimates from the Special Two-Day Season and regular season during 1994 indicated that less than 7% of lobster landings that season occurred after Labor Day.

### Comparison of estimated recreational landings to commercial landings

The estimated combined landings from the Special Two-Day Sport Season and the regular lobster fishing season were highly correlated with the total commercial landings (Pearson's Correlation Coefficient = 0.805;  $P = 0.05$ ) (Fig. 9A). Expressed as a percentage of total commercial landings, our recreational landings estimates have varied from 23% to 39% of commercial landings, but the percentage has been higher from 1999 through 2003 than in the five previous years (Fig. 9B).

## DISCUSSION

The Florida recreational spiny lobster fishery is perhaps the most intensive recreational lobster fishery on the globe. Within a 5-week-long period beginning with the state's Special Two-Day Sport Season held during the last week of July and continuing through the first week of September, the fishery over the past decade has landed, on average, c. 800 t of lobsters, an amount equal to c. 30% of the commercial fishery's total annual landings. Removal rates of legal-sized lobsters by recreational fishers at some locations in the Florida Keys during the Special Season have been estimated to be c. 90% (Eggleston et al. 2003). By comparison, Western Australia's recreational fishery for *Panulirus cygnus* has been estimated to land c. 626 t, but over a 7-month-long period, and this amount is equal to only c. 5% of commercial fishery landings (Melville-Smith & Anderton 2000). Other recreational lobster fisheries have reported landings no greater than 500 t, and most of those report landings far lower (reviewed by Melville-Smith et al. 2000). The only other recreational fishery for *P. argus* of which we are aware for which recreational landings have been estimated is located in Bermuda. Annual landings there have been estimated at 3.5 t (Melville-Smith et al. 2000). *P. argus* is undoubtedly landed throughout its range for personal consumption, with the possible exception of areas where such landings are expressly forbidden (e.g., Brazil and Mexico) (Melville-Smith et al. 2000). However, with the exception of the Bahamas, such landings are likely to be negligible.

The progressive increase in the sales of Florida's recreational spiny lobster license since its inception in the early 1990s suggests that there is the potential for increased expansion of the fishery. Yet, increased license sales did not result in increased fishing effort over the same period. Rather, fishing effort and landings during the Special Two-Day Sport Season varied without a discernable trend, and fishing effort during the regular season has actually decreased during recent seasons. The increase in license sales is likely the result of increased sales of Florida's saltwater fishing license (Florida Fish & Wildlife Conservation Commission unpubl. data), which is necessary to fish recreationally for all finfish species in the state's marine waters (Florida Statute 360, Chapter 68). The recreational spiny lobster license is a relatively inexpensive endorsement to this license. Therefore, we believe it likely that many of those purchasing a saltwater fishing license simply

include the lobster license with their purchase without having definite plans to fish for lobster.

Fishers' perceptions about annual lobster abundance to a certain extent influence license sales, and hence fishing effort. Annual landings by the commercial fishery decreased precipitously from 1999 to 2001, when landings were the lowest in more than 30 years, and during 2002 remained well below the long-term landings average experienced by the fishery over the past several decades, indicating a clear decline in lobster abundance. We note that license sales, after a nearly decade-long progressive increase, decreased noticeably following the 2000 season, the first of what were generally considered to be disappointing seasons, and continued the following season. The lower lobster abundance in these recent seasons also apparently influenced the fishing effort of those recreational fishers that did fish for lobster in the Florida Keys during the regular season, as the number of days spent fishing by survey respondents also decreased during those seasons.

Of considerable concern to Florida's fishery managers during these recent seasons has been a shift in landings allocations away from commercial fishers and toward the recreational lobster fishing sector, whose landings had equaled less than 30% of commercial landings throughout the 1990s, but increased rapidly from 1999 to 2001, when it reached nearly 40%. This sudden shift, coming at a time when the resource was exceedingly limited, sparked heightened user conflicts between the two fishing sectors and threatened to undermine the ongoing effort-reduction plan that had governed management of the commercial sector throughout much of the 1990s (see Hunt 1994 for a description of that plan). Though the proportion of lobster landings by the recreational fishery decreased during 2002, the state's fishery managers decided to reduce the daily bag limit of recreational lobster fishers to ensure no further shifts in the proportion of landings was accrued by recreational fishers. Beginning in 2003, recreational lobster fishers were limited to 6 lobsters per person per day only.

In addition to dealing with such inevitable user conflicts between recreational and commercial fishers, the state's fishery managers have also had to address socially based conflicts associated with the recreational fishery. The Special Two-Day Sport Season has been exceedingly unpopular with many of the residents of the Florida Keys, who have continually expressed their dismay to fisheries managers over the crowding caused by the numbers of vacationers who travel to the region for the week.

Their concerns were primarily caused by what they perceived to be widespread deleterious impacts to marine resources and noncompliance with daily bag limits by fishers brought about by the season's derby-like atmosphere. In 1992, the state's fisheries managers attempted to redirect fishing effort away from the Florida Keys during this season through a series of rule changes, including moving the season from its traditional weekend to the mid-week and doubling the daily lobster bag limit in all areas of the state except in the Florida Keys. However, those strategies had no measurable long-term effects on regional fishing effort. Because the Florida Keys is the premier vacation spot in Florida and the Special Two-Day Sport Season is held at the height of the summer vacation season, it was perhaps inevitable that such controls on fishing effort would have little effect. The distance many licensed lobster fishers travel to reach the Florida Keys underscores the popularity of this region as a vacation destination. Moreover, the Florida Keys is the only area of the state where lobsters are abundant in shallow water (<3 m) and consequently the only area where relatively inexperienced divers can actively participate in lobster fishing.

In the years since those major regulatory changes, there has continued to be political pressure from the local populace to either discontinue the Special Two-Day Sport Season or implement a limited-entry system that would curtail the number of people allowed to participate in the season in the Florida Keys. However, the state's fisheries managers were concerned that discontinuing the season would shift some portion of the fishing effort associated with those fishers who fish only during the Special Season, which we estimate to be nearly 20% of the licensed fishers who fish for lobster annually, to the regular season, thereby increasing recreational effort when commercial fishers are also active. Moreover, because many of the issues associated with the Two-Day Season have been primarily social, the state's fishery managers have been reluctant to implement any further regulatory changes to this season.

Florida's lobster fishery managers must consider the benefit provided by the recreational fishery to the economy of the Florida Keys. The socio-economic component of our 2001 mail survey provides the first quantitative evaluation of the economic value of this or, to our knowledge, any recreational spiny lobster fishery. The Florida Keys region is a tourism-based economy, and our survey clearly outlined the effect that visiting recreational lobster fishers, who accounted for more than 90% of the total monies

spent on lobster fishing during our survey period, have upon the region. By way of comparison, those lobster fishers spent c. 25% more per person-day than did general visitors to the Florida Keys during 2000–01 (Leeworthy & Wiley 2002). However, non-consumptive uses of the area's marine resources are perhaps more beneficial to the region's economy. Non-residents of the Florida Keys who visited the region to dive the coral reefs—perhaps the region's most valuable marine attraction—but not to fish for lobsters, spent more on a person-day basis than did recreational lobster fishers (Johns et al. 2003). Consequently, when assessing the economic benefits of the lobster fishery for the region, managers must also consider that benefit in light of environmental impacts that lobster fishing—resulting not only from recreational diving and but also from commercial trap gear—has upon the region's marine resources.

Our mail surveys remain the sole method by which the recreational fishery can be monitored in a comprehensive manner, and we believe them to be an effective tool by which we can monitor long-term trends in this fishing sector. Our response rates have ranged from 45% to 60% over our survey period, which is at the high-end of the range typically achieved with mail surveys of interest groups (Davis 1995 as cited in Melville-Smith & Anderton 2000). Higher rates, however, have been achieved in other mail surveys: Guillory (1998) reported a 79.4% response rate from blue crab fishers in Louisiana, United States. We note that our response rates did decrease when we increased the length of the questionnaires in order to gain more detailed information from survey recipients. Consequently, we are considering including a cash incentive in our future surveys via a lottery, similar to that described by Melville-Smith & Anderton (2000).

We do acknowledge, however, that potential biases exist in using mail surveys to gather data from recreational fishers. Foremost amongst these biases are the uncertainties associated with nonrespondents, who potentially may have very different fishing experiences than do those who respond to a survey (see Cowx 1991). We have conducted one telephone survey following one of our mail surveys and detected no differences between the nonrespondents' answers to specific questions we use to estimate landings or fishing effort and the answers we received from mail survey respondents (Florida Fish & Wildlife Conservation Commission unpubl. data). Though it would be desirable to conduct such follow-up surveys on a regular basis, they are labour-intensive, and we have not repeated this effort.

Another potential bias of mail surveys can result from the faulty memory of those surveyed or from an individual's penchant to exaggerate their catch out of pride. We evaluated this bias by conducting on-site creel surveys of recreational lobster fishers during our 2001 mail survey period (Florida Fish & Wildlife Conservation Commission unpubl. data). Lobster fishers were interviewed at boat docks and ramps immediately upon returning from their fishing trip for pertinent catch and effort information that could be compared with similar information from mail survey respondents. In many instances, port agents also directly examined the catch of those they interviewed. The agents also collected other information, such as fishing experience, to ensure that no differences in fisher demographics existed between those interviewed and survey respondents that could confound direct comparisons of the catch and effort data. Preliminary results indicate no differences in the catch data collected from the creel survey and those collected through mail surveys.

Until very recently the commercial spiny lobster fishery has garnered virtually all the attention of Florida's fishery managers. However, our annual surveys of recreational lobster fishers over the past decade have clearly indicated that the recreational spiny lobster fishery must also be considered so as to manage this valuable stock effectively. Yet, managers also face challenges beyond those of establishing strategies that allow the coexistence of this resource's user groups. They must ensure that such strategies incorporate the social and environmental concerns of nonuser groups as well. This challenge will undoubtedly be formidable. Florida's lobster fishery is concentrated in one of the state's premier tourist destinations, the Florida Keys, whose attraction lies primarily in its marine ecosystem and associated recreational activities. Consequently, managers will require a diverse array of information to formulate such a comprehensive strategy. Our annual mail surveys will continue to provide not only fishery-based information but also information that incorporates recreational fishers' motivations and opinions regarding fishery resources and associated social and environmental issues.

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